METHOD AND APPARATUS FOR TILT DETECTION IN AN INFORMATION-RECORDING MEDIUM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a optical system for optical recording, reproducing or erasing in an information-recording medium, and more particularly to a method and apparatus for tilt detection in said optical system.

2. Description of the Background Art

Figure 1 is a view showing a conventional optical pick-up apparatus for an optical system.

As shown in Figure 1, the optical pick-up 200 includes a laser diode 260 for generating light irradiated on the information-recording medium, a collimate lens 250 for changing the light generated from the laser diode 260 to a parallel light; a beam splitter 220 for refracting the optical axis of the parallel light to 90°, an objective lens 210 for collecting the refracted light and irradiating the refracted light on a track of the information-recording medium; a light-receiving lens 230 for forming an image of a reflected light on a photodiode when the light irradiated on the track of the information-recording medium is reflected from the information-recording medium; and a photodiode 240 for outputting a light amount signal corresponding to the light amount of the reflected light.

Figure 2 is a view showing a diffraction pattern of the light beam when there is not a tilt or a radial tilt.

Figure 3A and Figure 3B are a view showing a diffraction pattern of the light beam when there is a tilt or a radial shift. As shown in Figure 3A and Figure 3B, the diffraction pattern of the light beam shows an asymmetric distribution. In this respect, the darker portion of the drawing indicates that there is less light amount.

Figure 4 is a view showing four divided photo diode (A, B, C and D) in accordance with the conventional art.

As shown in Figure 4, when the push-pull method, one of methods for detecting a degree that the currently irradiated light is deviated from the track, is employed, a push-pull value is expressed by a difference between a sum of the light amount detected from the photo diode 240 (A, D) and the sum of the light amount detected from the photo diode 240 (B, C). When it is taken as a formula, it can be expressed by $P\_P = (A+D) - (B+C)$.

When the light is irradiated at an accurate position of the track, as shown in Figure 2, since the left and right light amount of the diffraction pattern are the same, the push-pull value is '0'. On the other hand, when irradiated off the accurate position of the track, the diffraction pattern shows an asymmetric distribution so as to yield a positive or a negative value of the push-pull value. Accordingly, it can be determined how far the presently irradiated light is deviated from the track according to the sign.

However, even though the light is accurately irradiated on the track of the information-recording medium 100, if the information-recording medium 100 is slanted, the light amounts of the left and right sides are different to each other. And when there happens a radial shift with an objective lens moving along the track, the diffraction pattern shows an asymmetric distribution so as to yield a

positive or a negative value of the push-pull value. Accordingly, it is not possible to know from the resultant push-pull value whether the asymmetric distribution is owing to the disk tilt or the radial tilt.

In other words, as shown in Figures 5A and 5B, since the tilt amount for the push-pull value and the slope of the radial shift amount are similar, there is little difference between the push-pull value according to the tilt amount and the push-pull value according to the radial shift amount.

SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to provide an optical pickup apparatus of an information-recording medium that is capable of precisely obtaining a direction and a degree of a tilt against the information-recording medium where the tilt and a shift are mixed.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, there is provided an optical pickup apparatus of an information-recording medium having a photo diode for detecting a light reflected from an information-recording medium and outputting a light amount signal according to the detected light amount; and a calculating unit for calculating a radial tilt amount by using the light amount signal, wherein the photodiode is divided into a plurality of cells which are identified as regions according to a light amount of the reflected light, based on which a tilt signal is detected.

To achieve the above objects, there is further provided a tilt detecting method of an information-recording medium including the steps of: detecting a

light amount of a region having a large change in a light amount and a light amount of a region having a small change in a light amount according to a variation of a tilt amount, by means of a photo diode; calculating a push-pull value of each region; and removing an influence of a radial shift by using the two push-pull values and obtaining a difference of the tilt amount.

The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

In the drawings:

Figure 1 is a view showing the construction of an optical pickup apparatus in accordance with a conventional art;

Figure 2 is a view showing a diffraction pattern of the light beam when a tilt or a radial shift is not generated in a land and a groove of the information-recording medium;

Figure 3A is a view showing a diffraction pattern of the light beam when a tilt is generated in a land and a groove of the information-recording medium;

Figure 3B is a view showing a diffraction pattern of the light beam when a

radial shift is generated in a land and a groove of the information-recording medium;

Figure 4 is a view showing a four-divided photodiode in accordance with the conventional art;

Figures 5A and 5B are graphs showing push-pull values (P_P) according to a variation of a tilt amount and push-pull values (P_P) according to a variation of a radial shift amount;

Figure 6 is a view showing the construction of a tilt detecting apparatus in accordance with a preferred embodiment of the present invention;

Figure 7 is a view showing a 8-divided photo diode in accordance with the preferred embodiment of the present invention;

Figures 8A and 8B are views showing a partial push-pull value (P1) according to a variation of a tilt amount and a partial push-pull value (P1) according to a variation of a radial shift amount;

Figures 9A and 9B are views showing a partial push-pull value (P2) according to a variation of a tilt amount and a partial push-pull value (P2) according to a variation of a radial shift amount;

Figure 10A is a graph showing a value 'T' according to a variation of a tilt amount when a radial shift amount is '0';

Figure 10B is a graph showing a value 'T' when the radial shift amount is '0';

Figure 11 is a graph showing how a tilt amount to be corrected is calculated when the value 'T' of Figure 10A is adopted to an optical pick-up; and

Figure 12 is a view showing a hologram pattern adopted in the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

A tilt detecting apparatus of the present invention is featured in that after a region having a large light amount variation and a region having a little light amount variation according to a variation of a tilt amount are detected by using a 8-divided photo diode, a push-pull value of each region is calculated, and an influence of a radial shift is removed by using the two push-pull values, and then a difference of the tilt amount to thereby detect an accurate tilt amount.

The operation of the tilt detecting apparatus will now be described in detail with reference to accompanying drawings.

Figure 6 is a view showing the construction of a tilt detecting apparatus in accordance with a preferred embodiment of the present invention.

As shown in Figure 6, a tilt detecting apparatus includes an information-recording medium 100; an optical pick-up 400 for detecting a slope of an light beam irradiated on the recording layer of the information-recording medium against an optical axis; and a calculating unit 500 for receiving a light amount signal and a tracking error signal from the optical pick-up 400, performing a calculation and outputting a tilt amount.

The optical pick-up 400 includes a laser diode 460 for generating a light to be irradiated on the information-recording medium 100, a collimate lens 450 for changing the light generated from the laser diode 460 to a parallel light; a beam splitter 420 for refracting an optical axis of the parallel light to 90°; an objective

lens 410 for collecting the refracted light and irradiating it on the information-recording medium 100; a light-receiving lens 430 for forming an image on a photo diode 440 by the reflected light as the light irradiated on the track of the information-recording medium 100 is reflected from the information-recording medium 100; and the photo diode 440 for outputting a light amount signal corresponding to the light amount of the reflected light.

The tilt detecting apparatus of the present invention has the same construction as that of the conventional art as shown in Figure 1, except that the former has the photo diode 440 and the calculating unit 500, descriptions of which, thus, are omitted.

Figure 7 is a view showing an 8-divided photo diode in accordance with the preferred embodiment of the present invention.

As shown in Figure 7, the 8-divided photo diode 440 includes eight divided diodes (A1, A2, B1, B2, C1, C2, D1, D2) as the four-divided photo diode regions are also diagonally divided.

The 8-divided photodiode 440 is adopted to the optical pick-up 400, the light of the first diffraction region 1 having much difference in the light amount by the tilt and the light of the third diffraction region 3 having a little difference in the light amount by the tilt can be separately detected.

In detail, in case of using the 8-divided photo diode 440, the push-pull value is expressed by a difference of the left and right light amounts of the diffraction patterns as shown in Figures 2 and 3. Accordingly, a difference between the sum of light amount of the left regions of the photo diode 440 (A1, A2, D1, D2) and the sum of light amount of the right regions of the photo diode 440 (B1, B2, C1, C2) is obtained. This is expressed by an equation (1):

$$P\_P = (A1+A2+D1+D2) - (B1+B2+C1+C2) \text{ ------------- } (1)$$

As mentioned above, since the first diffraction region 1 is where the light amount is much changed by the tilt of the information-recording medium 100, the light amount difference according to the change of the diffraction pattern by the tilt is concentrated on the regions A1, B1, C1 and D1 of the photo diode 440. In this manner, the left and right light amount difference is obtained by using the regions with the great change of the light amount, which can be expressed by equation (2):

$$P1 = (A1 + D1) - (B1 + C1) \text{ ------------------------ } (2)$$

A difference of left and right light amounts is obtained by using the regions with the small change of light amount, which can be expressed by equation (3):

$$P2 = (A2 + D2) - (B2 + C2) \text{ ------------------------ } (3)$$

Figures 8A and 8B are views showing a partial push-pull value (P1) according to a variation of a tilt amount and a partial push-pull value (P1) according to a variation of a radial shift amount.

As shown in Figures 8A and 8B, there is little difference in the partial push-pull values (P1) according to the tilt amount and the radial shift amount.

Namely, the influence of the tilt made to the partial push-pull value (P1) or the influence of the radial shift to the partial push-pull value (P1) are similar.

However, the case of a partial push-pull value (P2) is difference.

Figures 9A and 9B are views showing a partial push-pull value (P2) according to a variation of a tilt amount and a partial push-pull value (P2) according to a variation of a radial shift amount.

As shown in Figures 9A and 9B, the partial push-pull value (P2) is little influenced by the tilt amount, while it is much influenced by the radial shift amount.

In this relation, the influence from the radial shift can be minimized by equation (4):

$$T = P1 - kP2 = [(A1 + D1) - (B1 + C1)] - k[(A2 + D2) - (B2 + C2)] \text{ ---- } (4)$$

wherein 'k' is a constant to minimize the influence of the radial shift.

This will now be described with reference to Figures 10A and 10B.

Figure 10A is a graph showing a value 'T' according to a variation of a tilt amount when a radial shift amount is '0', and Figure 10B is a graph showing a value 'T' when the radial shift amount is '0'.

As shown in Figures 10A and 10B, in equation (4), by obtaining a difference between the partial push-pull values P1 and P2, 'k' for making the value of the radial shift to be '0' can be obtained. Through this process, the value 'T' can be obtained depending only on the tilt amount.

In order to simplify the above described computation process, the similar result can be obtained by using the left and right light amount difference of the upper portion of the diffraction pattern of the photo diode 440 or the left and right light amount difference of the lower portion of the diffraction pattern of the photo diode 440.

That is, it can be simplified to $T = (A1 - B1) - k(A2 - B2)$ or $T = (D1 - C1)$

– k(D2 – C2), wherein 'k' is a constant.

Figure 11 is a graph showing how a tilt amount to be corrected is calculated by using the obtained tilt value.

In Figure 11, a difference between the value 'T' when the radial shift amount is '0' and a pre-set tracking error value (TE) is obtained and the difference value is used as a tilt amount.

In a different embodiment of the present invention, in the tilt detecting apparatus, in case that the method for compensating a tilt adopts an astigmatism method, the diffraction pattern of beam in the photo diode is rotated by 90°, and accordingly, the value 'T' is computed by equation (5) with 90° rotation:

$$T = [(A1 + B1) - (C1 + D1)] - k^*[(A2 + B2) - (C2 + D2)] \text{ --------- } (5)$$

wherein 'k' is a constant.

Figure 12 is a view showing a hologram pattern adopted in the present invention.

As shown in Figure 12, a hologram (not shown) is installed in front of or behind the photo diode 440. After the reflected light diffracted at the information-recording medium 100 is transmitted through the objective lens, the refraction pattern is formed according to the shape of the photo diode and a partial light of a desired diffraction pattern is irradiated to the photo diode cell of a desired position. Then, an accurate tilt amount can be detected.

As so far described, the radial tilt detecting apparatus of the present invention has the following advantage.

That is, a portion of the reflected light diffracted at the information-recording medium is detected by using the 8-divided photo diode 440, the region

having a large difference in a light amount by the tilt and the region having a small difference in a light amount by the tilt in view of the characteristic of the reflected light are detected. And then, after push-pull values of each region are computed to remove an influence of the radial shift by using the two push-pull values, a corresponding difference between the tilt amounts, thereby obtaining an accurate tilt direction and degree of the information-recording medium 100.

As the present invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, it should also be understood that the above-described embodiments are not limited by any of the details of the foregoing description, unless otherwise specified, but rather should be construed broadly within its spirit and scope as defined in the appended claims, and therefore all changes and modifications that fall within the meets and bounds of the claims, or equivalence of such meets and bounds are therefore intended to be embraced by the appended claims.